METHOD FOR QUICK JOINING GOLF CLUB HEAD MEMBERS USING INFRARED RAYS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention utilizes infrared rays for quick joining a golf club head and, in particular, to using infrared rays to heat a filler metal which is inserted between a main head body and a striking plate to manufacture the golf club head.

2. Description of the Related Art

An infrared ray has a frequency in the electromagnetic spectrum in a range just below that of red light, and a quartz tube can radiate infrared rays in proportion to their temperature. An infrared ray can be used to join separate objects within a small bonding area, and provides rapid heating and cooling of said objects.

A conventional golf club head consists of a golf club head combined with a striking plate. The golf club head can be assembled utilizing a variety of methods, including mechanical insertion, glue, welding, and brazing, for example. Welding is, however, an unsuitable method for assembling the golf club head if the golf club head and striking plate are made of dissimilar categories of metal alloys, as this will result in a weak welding joint. Accordingly, if the golf club head and striking plate are made of dissimilar metal alloys, only mechanical insertion, glue, and brazing methods can be utilized. With regard to brazing, this method requires metallic filler to be disposed between the golf club head and the striking plate. The golf club head and striking plate are then heated in a furnace so that the metallic filler is melted, thereby closely filling in the gap between the golf club head and the striking plate. After cooling, the striking plate is then bonded to the golf club head.

The main head body of a conventional golf club head can be comprised of a variety of materials, including stainless steel, maraging steel, titanium alloy, aluminum alloy, and magnesium alloy, for example. The conventional striking plate can also be composed of a variety of materials, including titanium alloy, maraging steel, shape memory steel, and bulk amorphous alloy, for example. Generally, a conventional golf club head is made of stainless steel, such as 17-4PH, and the striking plate is made of titanium alloy, such as Ti-6Al-4V. During the process of joining the golf club head and striking plate, if a

conventional brazing method is employed, the speed at which the golf club head is heated is low (about 5-50°C per minute). In order to avoid detrimental effects caused by exposing members of the golf club head to high-temperature conditions over a long time, the brazing temperature ranges from approximately 0-50°C , and the metallic filler is melted for approximately 10-30 minutes. Accordingly, the liquid state of the metallic filler wets the members (base metals) of the golf club head, so that they may be joined together by this brazing method. Both high temperature and/or extended exposure of the joint during conventional brazing can generally result in dissolution of the joined substrates. In other words, in high-temperature conditions, a part of the golf club head and/or striking plate may be blended into the metallic filler. This effect is referred to as an alloying effect. Once the composition of the metallic filler is changed, fluidity and wettability of the metallic filler may be affected such that construction of the joint is weakened. In addition, a brittle intermetallic compound is formed between the metallic filler and the base metal of the golf club head, or between the metallic filler and the base metal of the striking plate. If the intermetallic compound becomes thick, mechanical strength and impact-resistance of the joint are weakened. Accordingly, when combining a golf club head and striking plate of dissimilar categories of alloys, mechanical insertion and gluing methods are preferred.

Hence, there is a need to overcome the problems associated with the conventional brazing method, in order to improve the performance of a golf club head formed from dissimilar categories of metal alloys. To this end, both the alloying affect and formation of an intermetallic compound should be avoided as much as possible, in order to increase reliability of the joined portion of the golf club head. Obviously, a shortened processing time and a rapid heating process can overcome the foregoing drawbacks of the conventional brazing method.

The present invention utilizes infrared rays for quick joining a golf club head in such a way to mitigate and/or overcome the above-listed problems.

SUMMARY OF THE INVENTION

The present invention utilizes infrared rays for quick joining a golf club head, and employs a geometrical optics device to focus and reflect infrared rays to increase the energy density and heating rate. The geometrical optics device preferably has an ellipsoid and parabolic reflector whose rear surface is plated with gold and cooled with water.

Thereby, the geometrical optics device has a preferred reflecting effect and is suitable for operation in high-temperature conditions. In order to increase efficiency and conserve power, infrared rays are transmitted through a quartz tube and focused on the joining area of the golf club head members. Since infrared rays are capable of rapid heating and cooling, the time required to join the golf club head members is shortened significantly. In comparison with a conventional heating rate of approximately 5-50°C/min, the heating rate of infrared rays is as high as 3000°C/min, and can therefore avoid exposing members of the golf club head to high-temperature conditions over an extended period of time. Accordingly, the golf club head can avoid the problems associated with extended exposure to high-temperature environments. In addition, the processing time of the present invention is precisely controlled by a processing temperature controller, so that the process temperature does not need to be limited to the range between 0 and 50°C over the melting point of the metallic filler. Accordingly, using infrared rays for joining a golf club head provides both automatic control and an increased manufacturing efficiency not found in the conventional brazing method.

The method of the present invention utilizes infrared rays for quick joining, and applies to a golf club head which consists of a main head body and a striking plate. The main head body and striking plate are made of different materials. Metallic filler is disposed between the main head body and the striking plate. Infrared rays are then used to melt the metallic filler, and to fill the gap between the main head body and the striking plate. The melted metallic filler is therefore rapidly wetted and joins the main head body and the striking plate in a shortened period of time. The main head body is made of a material selected from the group consisting of stainless steel, maraging steel, titanium alloy, aluminum alloy and magnesium alloy, for example. The striking plate is made of a material selected from the group consisting of titanium alloy, maraging steel, shape memory steel, and bulk amorphous alloy, for example.

Further scope of the applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings, which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

FIG. 1 is an exploded view of a method for quick joining a golf club head utilizing infrared rays in accordance with a first embodiment of the present invention;

FIG. 2 is an exploded view of a method for quick joining a golf club head utilizing infrared rays in accordance with a second embodiment of the present invention;

FIG. 3 is a symbol diagram of processing parameters a method for quick joining a golf club head utilizing infrared rays in accordance with the present invention;

FIG. 4a is an SEM (Scanned Electron Microscope) photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, Ag and 17-4PH at 1,000°C for 30 seconds in accordance with the present invention;

FIG. 4b is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, Ag and 17-4PH at 1,000°C for 120 seconds in accordance with the present invention;

FIG. 4c is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, Ag and 17-4PH at 1,000°C for 210 seconds in accordance with the present invention;

FIG. 4d is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, Ag and 17-4PH at 1,000°C for 300 seconds in accordance with the present invention;

FIG. 5 is an experimental data diagram of a shearing test for a joint consisting of Ti-6Al-4V, Ag and 17-4PH in accordance with the present invention;

FIG. 6a is a series of SEM photographs demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH at 800°C for 120 seconds in accordance with the present invention;

FIG. 6b is an EPMA (Electron Probe Microanalysis) data diagram analyzing the chemical composition of a joint consisted of Ti-6Al-4V, 72Ag-28Cu and 17-4PH at 800°C for 120 seconds in accordance with the present invention;

FIG. 7a is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH at 850°C for 30 seconds in accordance with the present invention;

FIG. 7b is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH at 850°C for 120 seconds in accordance with the present invention;

FIG. 7c is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH at 850°C for 300 seconds in accordance with the present invention;

FIG. 8 is an experimental data diagram of a shearing test for a joint consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH in accordance with the present invention;

FIG. 9a is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 95Ag-5Al and 17-4PH at 830°C for 300 seconds in accordance with the present invention;

FIG. 9b is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 95Ag-5Al and 17-4PH at 850°C for 120 seconds in accordance with the present invention;

FIG. 9c is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 95Ag-5Al and 17-4PH at 850°C for 300 seconds in accordance with the present invention;

FIG. 9d is an SEM photograph demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 95Ag-5Al and 17-4PH at 900°C for 120 seconds in accordance with the present invention; and

FIG. 10 is an experimental data diagram of a shearing test for a joint consisting of Ti-6Al-4V, 95Ag-5Al and 17-4PH in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

In utilizing infrared rays for quick joining a golf club head, the present invention adopts an infrared furnace of ULVAC SINKO-RIKO RHL-P610C. The infrared furnace has 6 quartz tubes (containing tungsten heating wire) and 6 parabolic reflectors, and can be operated at temperatures of up to 1,300°C. The infrared furnace is operated under argon

gas or a high vacuum less than $5*10^{-5}$ mbar, and the wavelength of the infrared rays preferably range between 0.76 and 1,000μm.

FIG. 1 is an exploded view of the method of using infrared rays for quick joining a golf club head in accordance with a first embodiment of the present invention. The golf club head consists of a plurality of parts, including a main head body 1, a striking plate 2 and a metallic filler member 3. Prior to the main head body 1 being combined with the striking plate 2, the metallic filler member 3 is disposed therebetween. Subsequently, infrared rays are used to heat and melt the metallic filler member 3. After cooling, the metallic filler member 3 can connect the main head body 1 with the striking plate 2. In this embodiment, the main head body 1 is made of stainless steel and the striking plate is made of titanium alloy. The material of the main head body 1 is selected from a 17-4PH stainless steel, which provides high strength, corrosion-resistance and good wettability. The material of the striking plate 2 is selected from a Ti-6Al-4V alloy, which provides high strength, corrosion-resistance and good wettability. The material of the metallic filler member 3 is selected from the group consisting of Ag-base fillers such as Ag, 72Ag-28Cu and 95Ag-5Al, Ni-base fillers, Cu-base fillers, and Ti-base fillers.

FIG. 2 is an exploded view of a method for quick joining a golf club head using infrared rays, in accordance with a second embodiment of the present invention. The golf club head includes a main head body 10, a weight member 20 and a metallic filler member 30. The material of the main head body 10 is selected from the group consisting of titanium alloy, Fe-base alloy, magnesium alloy, aluminum alloy, Fe-Mn-Al alloy, shape memory steel, tungsten alloy, copper alloy, nickel alloy, bulk amorphous alloy, nano-alloy, composite material and ceramic material, for example. The specific gravity of the weight member 20 is greater than that of the main head body 10, and the material of the weight member 20 is selected from the group consisting of tungsten, tungsten alloy, copper alloy and lead alloy, for example. The material of the metallic filler member 30 is selected from the group consisting of Ag-base fillers, Ni-base fillers, Cu-base fillers, and Ti-base fillers. Before the main head body 10 is combined with the weight member 20, the metallic filler member 30 is disposed therebetween. Subsequently, infrared rays are used to heat and melt the metallic filler member 30. After cooling, the metallic filler member 30 can connect the main head body 10 to the weight member 20. In order to avoid an alloying effect on the main head body 10 and the weight member 20, the heating rate of the

infrared furnace is not less than 1°C/sec, and more preferably 50°C/sec. The processing parameters for using infrared rays to join golf club head members, including the preheating temperature, heating rate, vacuum condition, processing temperature and time, are described more detail in FIG. 3.

The method of using infrared rays for quick joining the golf club head involves the use of an atmosphere. In other words, in order to avoid oxidation of the metallic filler member 10 during the process, the golf club head is processed in a vacuum or inert gas including nitrogen, argon, and/or helium, for example.

FIGS. 4a through 4d are SEM photographs demonstrating the method of utilizing infrared rays for a joint composed of Ti-6Al-4V, Ag and 17-4PH at 1,000°C for 30 seconds. As can be seen in these photographs, the alloying effect on the inner faces of the joint composed of Ti-6Al-4V, Ag and 17-4PH has been suppressed.

FIG. 5 is an experimental data diagram of a shearing test for a joint consisting of Ti-6Al-4V, Ag and 17-4PH. As can be seen in this data, high joint quality is achieved if the processing temperature is low or the processing time is short. The alloying effect between Ti-6Al-4V and Ag, or between Ag and 17-4PH steel, is greatly decreased by the use of infrared rays for quick joining the golf club members. The average shear strength of pure silver filler is as high as 91.7 MPa. In addition, a compact joint is accomplished by the use of infrared heating.

FIG. 6a are SEM photographs demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH at 800°C for 120 seconds. FIG. 6b is an EPMA data diagram analyzing the chemical composition of a joint consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH at 800°C for 120 seconds. In FIG. 6a, the Ti-Cu compounds (TiCu, Ti_2Cu_3, $TiCu_4$) are observed at the interface between Ti-6Al-4V and 72Ag-28Cu. It can also shown that Cu atoms of the metallic filler (72Ag-28Cu) react with Ti-6Al-4V, but Ag atoms do not react with Ti-6Al-4V. Thus, there is a decrease in Cu content from the 72Ag-28Cu filler.

FIGS. 7a through 7c are SEM photographs demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH at 850°C for various processing times. Referring to FIGS. 6 and 7, as the processing temperature is increased or the heating time is prolonged, the thickness of a reaction layer defined between the metallic filler (72Ag-28Cu) and the base metal (T-6Al-4V) becomes thicker. When

heating time is limited to 30 seconds, the molten metallic filler does not have time to completely react with the base metal. The Cu atoms of the metallic filler (72Ag-28Cu) react with Ti-6Al-4V, but Ag atoms do not react with Ti-6Al-4V. Thus, there is a decrease of Cu content from the 72Ag-28Cu filler. As the heating time is increased, the original eutectic microstructure is changed into a hypo-eutectic microstructure, due to depletion of Cu content from the molten 72Ag-28Cu filler. Consequently, a large scale of Ag-enriched phase exists in the joint, as is illustrated in FIGS. 7b and 7c.

FIG. 8 is an experimental data diagram of a shear test for a joint consisting of Ti-6Al-4V, 72Ag-28Cu and 17-4PH in various processing conditions. The average maximum shear strength is about 96.4 MPa at 800°C of processing temperature for 120 seconds of heating time. It can be found that the shear strength of the joint may tends to decrease as the processing temperature is increased or the heating time is prolonged. This can be attributed to the growth of continuous reaction layer(s) in the interface, which thereby cause a decrease in the shear strength of the joint. The result of the metallic fillers in this embodiment is similar to that of pure silver. Improved shear strength of the joint may be obtained even if the processing temperature is low or the heating time is short. In other words, using infrared rays for quick joining golf club head members can suppress the interfacial reactions between the filler of 72Ag-28Cu and the base metal of Ti-6Al-4V, or between the filler of 72Ag-28Cu and the base metal of 17-4PH.

FIGS. 9a through 9d are SEM photographs demonstrating the use of infrared rays to join materials consisting of Ti-6Al-4V, 95Ag-5Al and 17-4PH at various degrees centigrade for a predetermined processing time. In FIGS. 9a through 9d, no continuous reaction layer has been identified in the joint between the metallic filler and the base metals. EPMA analysis for chemical composition cannot be processed accurately, because the thickness of the reaction layer is less than 1 μm.

[0042] FIG. 10 is an experimental data diagram of a shear test for a joint consisting of Ti-6Al-4V, 95Ag-5A1 and 17-4PH in various processing conditions. The result of the metallic filler (95Ag-5A1) in this embodiment is similar to that of pure silver. Using infrared rays for quick joining golf club head members can suppress both the interfacial reaction as well as the alloying effect between the filler and the base metals. Thus, improved strength of the joint may be obtained even if the processing temperature and/or time is decreased.

Using infrared rays for quick joining the golf club head suppresses growth of interfacial intermetallic compound(s), thereby reducing brittleness, increasing product quality and manufacturing efficiency, and decreasing the rate of power consumption. Therefore, infrared rays can be widely applied in joining golf club head members. The method of the present invention greatly increases the quality of the golf club head product and significantly decreases manufacturing costs.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.